CLAIMS

The embodiments of the invention in ~~which an exclusive property or privilege~~ is cla~~imed~~
defined as follows:

1-20 (cancelled)

21. (New) A method of forming/~~defining and solving~~ a model of the power network to effect
control of voltages and power flows in a power system, comprising the steps of:

obtaining on-line/simulated data of open/close status of switches and circuit breakers in
the power network, and reading data of operating limits of the network
components including PV-node, a generator-node where Real-Power-P and
Voltage-Magnitude-V are given/assigned/specified/set, generators maximum and
minimum reactive power generation capability limits and transformers tap position
limits,

obtaining on-line readings of given/assigned/specified/set real and reactive power at PQ-
nodes, the load-nodes where Real-Power-P and Reactive-Power-Q are
given/assigned/specified/set, real power and voltage magnitude at PV-nodes,
voltage magnitude and angle at the reference/slack node, and transformer turns
ratios, which are the controlled variables/parameters,

initiating loadflow calculation with initial approximate/guess solution of the same voltage
magnitude and angle as those of the slack/reference node for all the other nodes
referred to as the slack-start,

forming and storing factorized gain matrices $[Y\theta]$ and $[YV]$ using the same indexing and
addressing information for both as they are of the same dimension and sparsity
structure, wherein said $[Y\theta]$ relate vector of modified real power mismatches $[RP]$
to angle corrections vector $[\Delta\theta]$ in equation $[RP] = [Y\theta] [\Delta\theta]$ referred to as P-θ
sub-problem, and said $[YV]$ relate vector of modified reactive power mismatches
$[RQ]$ to voltage magnitude corrections vector $[\Delta V]$ in equation $[RQ] = [YV] [\Delta V]$
referred to as Q-V sub-problem,

restricting transformation/rotation angle Φ_p to maximum -48° in determining transformed
real and reactive power mismatch as,

$$\Delta P_p' = \Delta P_p Cos\Phi_p + \Delta Q_p Sin\Phi_p \qquad \text{-for PQ-nodes} \qquad (23)$$

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$$\Delta Q_p' = \Delta Q_p Cos\Phi_p - \Delta P_p Sin\Phi_p \qquad \text{-for PQ-nodes} \qquad (24)$$

Wherein, ΔP_p and ΔQ_p are real and reactive power mismatches at node-p, calculating modified real and reactive power mismatches as given in the following in the most general form of equations that take different form for different Super Super Decoupled Loadflow model:

$$RP_p = [\Delta P_p' + (G_{pp}'/B_{pp}') \Delta Q_p'] / V_p^2 \qquad \text{-for PQ-nodes} \qquad (17)$$
$$RQ_p = [\Delta Q_p' - (G_{pp}'/B_{pp}') \Delta P_p'] / V_p \qquad \text{-for PQ-nodes} \qquad (18)$$

and calculating modified real power mismatch at a PV-node as,

$$RP_p = \Delta P_p/(K_p V_p^2) \qquad \text{-for PV-nodes} \qquad (19)$$
$$\text{Wherein,} \qquad K_p = \text{Absolute} (B_{pp}/Y\theta_{pp}) \qquad (29)$$

and V_p is voltage magnitude at node-p, and B_{pp} is imaginary part of the diagonal element Y_{pp} of the admittance matrix without network shunts, and $Y\theta_{pp}$ is the diagonal element of the gain matrix $[Y\theta]$,

using network shunt parameter b_p' that appears in diagonal elements of gain matrix $[YV]$ as given in the following in the most general form of equations that take different form for different loadflow model:

$$b_p' = -b_p Cos\Phi_p + [QSH_p' - (G_{pp}'/B_{pp}') PSH_p'] / V_s^2 \qquad \text{or}$$
$$b_p' = 2[QSH_p' - (G_{pp}'/B_{pp}') PSH_p'] / V_s^2 \qquad (22)$$

wherein, G_{pp}' and B_{pp}' are the real and imaginary parts of the transformed diagonal element Y_{pp}' of the admittance matrix without network shunts, b_p is network shunt susceptance at node-p, V_s is slack-node voltage magnitude, and

$$PSH_p' = PSH_p Cos\Phi_p + QSH_p Sin\Phi_p \qquad \text{-for PQ-nodes} \qquad (25)$$

$$QSH_p' = QSH_p Cos\Phi_p - PSH_p Sin\Phi_p \qquad \text{-for PQ-nodes} \qquad (26)$$

wherein, PSH_p, and QSH_p are given/specified/scheduled/set real and reactive power respectively,

performing loadflow calculation by solving a super decoupled loadflow model of the power network defined by set of equations $[RP] = [Y\theta] [\Delta\theta]$ and $[RQ] = [YV]$

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[ΔV] employing successive (1θ, 1V) iteration scheme, wherein each iteration involves one calculation of [RP] and [Δθ] to update voltage angle vector [θ] and then one calculation of [RQ] and [ΔV] to update voltage magnitude vector [V], to calculate values of the voltage angle and the voltage magnitude at PQ-nodes, voltage angle and reactive power generation at PV-nodes, and turns ratio of tap-changing transformers in dependence on the set of said obtained-online readings, or given/scheduled/specified/set values of controlled variables/parameters and physical limits of operation of the network components,

evaluating loadflow calculation for any of the over loaded power network components and for under/over voltage at any of the network nodes,

correcting one or more controlled parameters and repeating the calculating, performing, evaluating, and correcting steps until evaluating step finds no over loaded components and no under/over voltages in the power network, and

effecting a change in the power flowing through network components and voltage magnitudes and angles at the nodes of the power network by actually implementing the finally obtained values of controlled variables/parameters after evaluating step finds a good power system or alternatively a power network without any overloaded components and under/over voltages, which finally obtained controlled variables/parameters however are stored in case of simulation for acting upon fast in case the simulated event actually occurs.

22. (New) A method as defined in claim-21 wherein loadflow calculation involving formation and solution of super super decoupled loadflow model, employing simultaneous (1V, 1θ) iteration scheme is characterized in that it involve only one time calculation of real and reactive power mismatches in an iteration along with modified real power mismatch calculation, depending on super super decoupled loadflow model used, either by:

$$RP_p = \; [(\Delta P_p/V_p) - \sum_{q=1}^{m} G_{pq}\Delta V_q] \, / \, V_p \qquad \text{-for all nodes} \qquad \text{or} \qquad (74)$$

$$RP_p = \; [(\Delta P_p/V_p) - \sum_{q=1}^{m} G_{pq}\Delta V_q \; - (g_p'\Delta V_p)] \, / \, V_p \quad \text{-for PQ-nodes, and} \qquad (75)$$

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$$RP_p = [(\Delta P_p/V_p) - \sum_{q=1}^{m} G_{pq}\Delta V_q] / V_p \qquad \text{-for PV-nodes} \qquad (76)$$

OR

$$RP_p = [\{[\Delta P_p' + (G_{pp}'/B_{pp}')\Delta Q_p'] / V_p\} - (g_p'\Delta V_p)] / V_p \quad \text{-for PQ-nodes} \qquad (92)$$

$$RP_p = [(\Delta P_p/V_p) - \sum_{q=1}^{m} G_{pq}\Delta V_q] / (K_p * V_p) \qquad \text{-for PV-nodes} \qquad (93)$$

wherein, m is the number of PQ-nodes, and the symbol 'Δ' preceding any variable represents mismatch or correction in the variable.

23. (New) A system for controlling generator and transformer voltages in an electrical power utility containing plurality of electromechanical rotating machines, transformers and electrical loads connected in a network, each machine having a reactive power characteristic and an excitation element which is controllable for adjusting the reactive power generated or absorbed by the machine, and some of the transformers each having a tap changing element which is controllable for adjusting turns ratio or alternatively terminal voltage of the transformer, said system comprising:

means defining and solving one of the Super Super Decoupled Loadflow models of the power network characterized in claim-21 or claim-22 for providing an indication of the quantity of reactive power to be supplied by each generator including the slack/reference node generator, and for providing an indication of turns ratio of each tap-changing transformer in dependence on the set of obtained-online readings or given/specified/set controlled network variables/parameters, and physical limits of operation of the network components,

machine control means connected to the said means defining and solving one of the Super Super Decoupled Loadflow models of the power network and to the excitation elements of the rotating machines for controlling the operation of the excitation elements of machines to produce or absorb the amount of reactive power indicated by said means defining and solving one of the Super Super Decoupled Loadflow models of the power network in dependence on the set of obtained-online readings or given/specified/set controlled network variables/parameters, and physical limits

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of excitation elements,

transformer tap position control means connected to the said means defining and solving one of the Super Super Decoupled Loadflow models of the power network and to the tap changing elements of the controllable transformers for controlling the operation of the tap changing elements to adjust the turns ratios of transformers indicated by the said means defining and solving Super Super Decoupled Loadflow model of the power network in dependence on the set of obtained-online readings or given/specified/set controlled network variables/parameters, and operating limits of the tap-changing elements.

24. (New) A system as defined in claim-23 wherein the power network includes a plurality of nodes each connected to at least one of: a slack/reference generator; a rotating machine; and an electrical load, and the said means defining and solving one of the Super Super Decoup;ed Loadflow models of the power network receives representations of selected values of the real and reactive power flow from each machine and to each load, and the model is operative for producing calculated values for the reactive power quantity to be produced or absorbed by each machine.

25. (New) A system as defined in claim-24 wherein the power network further has at least one transformer having an adjustable transformer turns ratio, and the said means defining and solving one of the Super Super Decoupled Loadflow models of the power network is further operative for producing a calculated value of the transformer transformation/turns ratio.

26. (New) A system as defined in claim-23 wherein said machine control means are connected to said excitation element of each machine for controlling the operation of the excitation element of each machine, and wherein said transformer turns ratio control means are connected to said transformer tap changing element of each transformer for controlling the operation of the tap changing element of each transformer.

27. (New) A method for controlling generator and transformer voltages in an electrical power utility containing plurality of electromechanical rotating machines, transformers and electrical loads connected in a network, each machine having a reactive power

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characteristic and excitation element which is controllable for adjusting the reactive power generated or absorbed by the machine, and some of the transformers each having tap changing element which is controllable for adjusting turns ratio or alternatively terminal voltage of the transformer, said method comprising:

creating and solving any of the said Super Super Decoupled Loadflow models of the power network as characterized in claim-21 or claim-22 for providing an indication of turns ratio of each of the tap-changing transformers and the quantity of reactive power to be supplied by each generator in dependence on the set of obtained-online readings or given/specified/set controlled network variables/parameters, and physical limits of operation of the network components,

controlling the operation of the excitation elements of machines to produce or absorb the amount of reactive power, and controlling tap changing elements of transformers to adjust transformer turns ratio indicated by means creating/forming/defining and solving any of the said Super Super Decoupled Loadflow models as characterized in claim-21 or claim-22 in dependence on the set of obtained-online readings or given/specified/set controlled network variables/parameters, and physical limits of operation of the network components.

28. (New) A method as defined in claim-27 wherein said step of controlling is carried out to control the excitation element of each machine.

29. (New) A method as defined in claim-27 wherein said step of controlling is carried out to control the tap-changing element of each controllable transformer.